IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
R. Tayrani *et al.*	:	Group Art Unit 2817
Serial No. 10/688,368	:	Examiner: Choe, Henry
Filing Date: 10/17/2003	:	Date: February 4, 2005
For: EFFICIENT BROADBAND	:	

AFFIDAVIT UNDER 37 C.F.R. 1.131

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

We, Reza Tayrani and Clifford Meyers, hereby declare that we are the inventors of the EFFICIENT BROADBAND SWITCHING-MODE AMPLIFIER disclosed and claimed in the above-identified patent application.

Enclosed herewith is a copy of an invention disclosure, which shows that the invention was conceived by us on or before August 29, 2002. We worked diligently on the invention from conception until the application was filed October 17, 2003.

We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

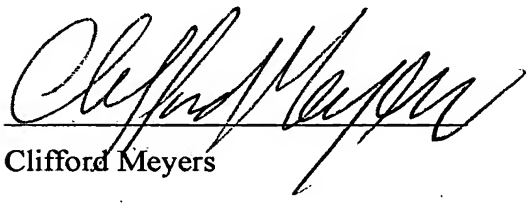
Full Name of Inventor: Reza Tayrani
Address: Marina Del Rey, CA
Citizenship: US

Reza Tayrani — Date: 2/16/05

Full Name of Inventor: Clifford Meyers

Address: Los Angeles, CA

Citizenship: US



Clifford Meyers

2/10/2005

Date

Raytheon

MAR 0 1 2005 PATENT & TRADEMARK

Invention Disclosure Questionnaire

10-5876-2PC (6/00)

File 2/5/2003

Raytheon Proprietary

- Complete the information in the spaces provided. Use the TAB key to advance to the next field. Shift-TAB will move the cursor back one field. Either X or Space-bar can be used to check boxes where required.

Prepare the Invention Disclosure Form, except for the information on page 3. The original should be signed and witnessed where indicated. Send the original and three copies directly to the Regional Patent Engineer (see below). Have a copy reviewed and annotated by your department manager (through your immediate supervisor), and then by the manager of the program office or business area most likely to benefit from protection (via patent or trade secret) of your invention. Once you receive the appropriate comments and signatures, the executed copy and six additional copies should also be sent to the Regional Patent Engineer at (see attached instructions):

Inventors at ELCAN, ROSI, and sites in CA or AZ: Intellectual Property & Licensing Dept., Raytheon Company, 2000 East El Segundo Blvd (EO/E01/E150), El Segundo, CA 90245; Texas area: Intellectual Property & Licensing Dept., Raytheon Company, 13510 N. Central Expressway, M/S 200, Dallas, TX 75243; Northeast Region: Intellectual Property & Licensing Dept., Raytheon Company, 141 Spring Street, Lexington, MA 02421.

1. TITLE OF INVENTION

A Highly Efficient Broadband Class E Push-Pull Amplifier

2. INVENTOR(S) (If more than 3, identify additional inventors in Section 14 and check this box ☒)

(A) NAME (first, middle, last)	EMPLOYEE ID	PHONE	FAX NO.	COMPANY & SEGMENT	DEPT NUMBER
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E-MAIL: rtayrani@west.raytheon.com	MANAGER: Ed Wallace	

23-0641

(B) NAME (first, middle, last)	EMPLOYEE ID	PHONE	FAX NO.	COMPANY & SEGMENT	DEPT NUMBER
Clifford Meyers	HAC83287	310-647-8107	310.647.358	ES/Integrated Systems	290

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1887 Greenfield Ave. #306 LA, CA 90025	us	2000 East Imperial Hwy PO Box 902 RE R01/A511 El Segundo, CA 90245
E-MAIL: cmeyers@raytheon.com <cmeyers@raytheon.com>	MANAGER	

(C) NAME (first, middle, last)	EMPLOYEE ID	PHONE	FAX NO.	COMPANY & SEGMENT	DEPT NUMBER

HOME ADDRESS (street, city, state, zip)	CITIZENSHIP	COMPANY MAIL/ADDRESS
		5
E-MAIL:	MANAGER	

Patent Department will determine legal inventorship

3. PROOF OF CONCEPTION

A. BY WHOM WAS FIRST DESCRIPTION WRITTEN OR DRAWING MADE?	DATE CONCEIVED	ACCT. CHARGED (TIME/MATERIAL)	LOCATION OF FIRST DESCRIPTION / DRAWING (TECHNICAL NOTEBOOK NO. AND PAGES)
Dr. Reza Tayrani	5/19/2002	NP1ARD3C12	presentation file, Office computer

B. TO WHOM WAS INVENTION FIRST DISCLOSED?	DATE DISCLOSED	MANNER OF DISCLOSURE
Cliff Meyers	5/25/2002	Meeting

PATENTS AND LICENSING USE ONLY

A Highly Efficient Broadband Class E Push-Pull Amplifier	DATE RECEIVED ON PATENTS & LICENSING RECEIVED JUL 09 2002	PATENT DOCKET NUMBER 02W135

4. REDUCTION TO PRACTICE

A. WAS A DEVICE EMBODYING THE INVENTION CONSTRUCTED AND TESTED OR THE PROCESS PRACTICED?	YES ☐ NO ☒	BY WHOM	DATE STARTED	DATE COMPLETED	ACCT. CHARGED (TIME/MATERIAL)
		Dr. Reza Tayrani			

B. PRESENT LOCATION OF DEVICE AND ALL DOCUMENTS SHOWING REDUCTION TO PRACTICE

5. RELATIONSHIP TO GOVERNMENT CONTRACT

A. WAS THIS INVENTION CONCEIVED AND/OR REDUCED TO PRACTICE UNDER GOVERNMENT CONTRACT?	YES ☐ NO ☒	CONTRACT NUMBER AND TITLE

B. TO ASSIST RAYTHEON IN COMPLYING WITH GOVERNMENT REPORTING REQUIREMENTS, PLEASE PROVIDE CONTACT IN GOVERNMENT AGENCY AND RAYTHEON CONTRACTS DEPARTMENT (IF KNOWN).

6. RELATIONSHIP TO COMPANY-FUNDED PROGRAM

A. WAS THIS INVENTION CONCEIVED AND/OR REDUCED TO PRACTICE AS PART OF A COMPANY-FUNDED PROGRAM/PROJECT?	YES ☒ NO ☐	IDENTIFY PROJECT TITLE, NUMBER, ETC.
		Raytheon "Idea Program"

7. RELATED DOCUMENTS

A. ARE THERE ANY RELATED INVENTION DISCLOSURES OR PATENT APPLICATIONS?	YES ☐ NO ☒	IDENTIFY FILE OR CASE NUMBER, ETC.
B. ARE THERE ANY RELATED ISSUED PATENTS OR TECHNICAL PUBLICATIONS?	YES ☐ NO ☒	IDENTIFY

8. USE, COMMERCIALIZATION AND FOREIGN MARKETS

A. ARE YOU AWARE OF ANY POTENTIAL COMMERCIAL APPLICATIONS FOR THE INVENTION?	YES ☒ NO ☐	IDENTIFY POTENTIAL CUSTOMER, APPLICATION, TIME FRAME
		commercial wireless personal communication Products, Nokai, 2002-2005
B. ARE YOU AWARE OF ANY FOREIGN MARKETS FOR THIS INVENTION?	YES ☒ NO ☐	IDENTIFY COUNTRIES, APPLICATIONS, TIME FRAME
		Japan, commercial wireless personal communication Products, NEC, 2002-2005
C. HAS THE INVENTION BEEN OR IS THE INVENTION TO BE INCORPORATED INTO A COMPANY PRODUCT OR PROGRAM?	YES ☒ NO ☐	PRODUCT(S) OR PROGRAM(S), TIME FRAME
		Space Based Radar

PATENTS AND LICENSING USE ONLY

A Highly Efficient Broadband Class E Push-Pull Amplifier	DATE RECEIVED ON PATENTS & LICENSING RECEIVED JUL 09 2002	PATENT DOCKET NUMBER 02W135

9. DEPARTMENT MANAGER COMMENTS TO PATENT EVALUATION COMMITTEE

This invention introduces a new class of broadband switching mode push-pull high power, high efficiency amplifier that utilizes a miniature wideband slot-line balun. Such highly efficient HPAs are needed for many defense and commercial applications including Spaced Based Radar (SBR) and digital RF transmitters based on Delta-Sigma DSP controlled chip sets.

Dr. Reza Tayrani's invention provides an elegant solution by utilizing a new class of miniature broadband baluns that are suitable for direct integration in the GaAs MMIC technology. By applying this device and a unique design methodology for the design of switching mode power amplifiers, highly efficient HPAs can be designed. By applying these highly efficient HPAs to our avionics systems, Raytheon will be able to demonstrate a leadership position in reducing cost, size, and weight of the Raytheon phased array radar systems.

NAME Ed Wallace	SIGNATURE S Wallace	DATE 6/24/2002 7/2/02	PHONE 310-334-7503

10. PROGRAM OR BUSINESS OFFICE COMMENTS TO PATENT EVALUATION COMMITTEE

Low cost, low weight, broadband and highly efficeint HPAs are critical components of any advanced T/R modules for applications in phased array spaced based radar and other avionic systems where efficency is a primum. Successful deployment of these modules are important to our major avionics programs including F/A18 AESA and MESA.

NAME Cliff Meyers	SIGNATURE Cliff Meyers	DATE 7/2/02	PHONE 310-647 810

11. SUPERVISOR: please affirm the charge number and program data provided in sections 3, 4, 5, and 6 of this disclosure.

SUPERVISOR NAME Ed Wallace	SIGNATURE S Wallace	DATE 7/2/02	PHONE 310-3347503

PATENTS AND LICENSING USE ONLY

A Highly Efficient Broadband Class E Push-Pull Amplifier	DATE RECEIVED RAYTHEON PATENTS & LICENSING RECEIVED JUL 09 2002	PATENT DOCKET NUMBER 02W135

TITLE OF INVENTION

A Highly Efficient Broadband Class E Push-Pull Amplifier

INVENTOR(S) (Additional Inventors may be listed in Section 14)

Dr. Reza Tayrani	Clifford Meyers	

12. **PUBLICATION, SALE, OR PUBLIC USE**

A. HAS THE INVENTION BEEN DISCLOSED TO A THIRD PARTY WITHOUT THE EXECUTION OF A NON-DISCLOSURE, PROPRIETARY, OR OTHER CONFIDENTIALITY AGREEMENT?	YES ☐ NO ☒	DATE	TO WHOM
B. HAS THE INVENTION BEEN USED, DISCUSSED, DEMONSTRATED OR OTHERWISE DISCLOSED OUTSIDE THE COMPANY (SUCH AS TO A VENDOR OR CUSTOMER)?	YES ☐ NO ☒	DATE	TO/FOR WHOM (COMPANY/PERSON)
C. HAS THE INVENTION BEEN SOLD OR OFFERED FOR SALE?	YES ☐ NO ☒	DATE	TO WHOM
D. IS THERE A PUBLICATION OR PUBLIC PRESENTATION RELATED TO THE INVENTION? (This includes the Internet)	YES ☐ NO ☒	DATE	IDENTIFY
E. HAS A MANUSCRIPT DESCRIBING THE INVENTION BEEN SUBMITTED FOR PUBLICATION?	YES ☐ NO ☒	DATE	TO WHOM
F. IF THE ANSWER TO E. WAS YES, HAS THE MANUSCRIPT BEEN ACCEPTED FOR PUBLICATION?	YES ☐ NO ☐	DATE	WHEN AND WHERE WILL IT BE PUBLISHED?

INVENTOR(S) SIGN AND DATE: R. Tayrani 6/27/02 C. Meyers 7/2/02

WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN	J.A. Maupin	6/27/02		GABRIEL MARCA	7/03/02

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A Highly Efficient Broadband Class E Push-Pull Amplifier	DATE RECEIVED RAYTHEON PATENTS & LICENSING RECEIVED JUL 09 2002	PATENT DOCKET NUMBER 02W135

13. SUMMARY OF THE INVENTIC

A. STATEMENT OF THE PROBLEM S_ _VED BY THE INVENTION

This invention introduces a new class of broadband highly efficient push-pull HPAs that are based on the unique properties of uniplanar slotline T-junctions and the switching mode operation of the GaAs amplifiers. Currently, highly efficient (~ 80-90%) microwave and RF power amplifiers do not exists due several design and implentation issues that have been addressed in this disclosure.

B. PRIOR ATTEMPTS OF OTHERS TO SOLVE THIS PROBLEM

The prior attempts of others to solve this problem is rather limited in the GaAs MMIC technology mainly due to the following reasons:

1. The microwave balun is a complex device to realize in GaAs MMIC technology and therefore the prior arts have yielded a limited bandwidth and a high insertion loss at X-band.

2. Published data on push-pull amplifiers show that they are operated as amplifiers in such classes as A, B or C with the PAE (power added efficiency) of less than 50% at X-band.

C. HOW YOUR INVENTION SOLVED THIS PROBLEM

Our approach to the design of a broaband push-pull highly efficient (PAE 80%) amplifier would eliminate the above mentioned performance limitations by:

1- Utilizing a new slotline blun which has a demonstrated low loss(<1 dB) and a broad frequency band (1-20 GHz).

2- By designing the amplifiers to operate in a highly efficient switching mode (class-E), we have shown PAE >90% at S-band and 70% at X-band can be achieved.

3- By utilizing these two unique design approaches in conjunction with the MMIC technology, a new generation of highly efficient HPAs can be offered. These HPAs are enabling componenets suitable for insertion in spaced based radar and other avionics systems where efficiency is a premium.

D. WHY YOU BELIEVE THAT THE INVENTION IS NEW (Specifically point out all novel features)

To our knowledge, after extensive literature serach, we have been unable to find a similar circuit concept. The unique features of our approach are:

1- A new design methodology, especially suitable for switching mode amplifiers . The four step design is based on time domain and Harmonic Balance analysis of the entire push-pull class-E HPA.

2- Utilization of a new miniature slotline balun suitable for integration in GaAs MMIC technology.

3- Design the amplifier for operation in a highly efficient switchining mode (class-E) rather than class A, B, or C.

14. DETAILED DESCRIPTION.

Use the Invention Disclosure Continuation Sheet to provide a detailed written description of your invention, using as many pages as necessary. Be certain to include a description of the "best mode" or best means of practicing the invention known to you at this time. You may insert figures, tables, and photos into this section, or you can attach copies of relevant proposals, prior art, or other documentation that will assist the Patent Evaluation Committee in fully considering your invention. (Note: Please place information on additional inventors first in this section).

INVENTOR(S) SIGN AND DATE: 6/27/02 7/2/02

WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN		6/27/02			7/03/02

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A Highly Efficient Broadband Class E Push-Pull Amplifier	DATE RECEIVED RAYTHEON PATENTS & LICENSING RECEIVED JUL 09 2002	PATENT DOCKET NUMBER 02W135

This invention introduces a new class of highly efficient, tunable push-pull Class-E (switching mode) High Power Amplifiers (HPAs). Such highly efficient HPAs are needed for many defense and commercial applications including Spaced Based Radar (SBR) and digital RF transmitters based on Delta-Sigma DSP controlled chip sets.

The limited available published data on the monolithic push-pull amplifiers show that the majority of these designs are based on class A, B, A-B or C. The power added efficiency (PAE) for these classes of amplifiers are inherently low due to the power dissipation within the active device and within the 180 degrees combining circuit (balun) used as part of the HPA's output matching network (OMN). Typical PAE of around 50% at X-band have been reported by several authors. However, such low PAE is not suitable for SBR applications where PAE of more 70% is desirable. Prior attempts of others to solve this problem have not been successful due to the followings:

1. The microwave baluns used thus far in push-pull HPAs are complex topology circuits and are found to be quite lossy when realized in GaAs MMIC technology. The prior arts have demonstrated wide operational bandwidth at the expense of a rather high circuit insertion loss (2 dB at X-band). However, as shown in Figure 1, the balun circuit loss drastically reduces amplifier's PAE.

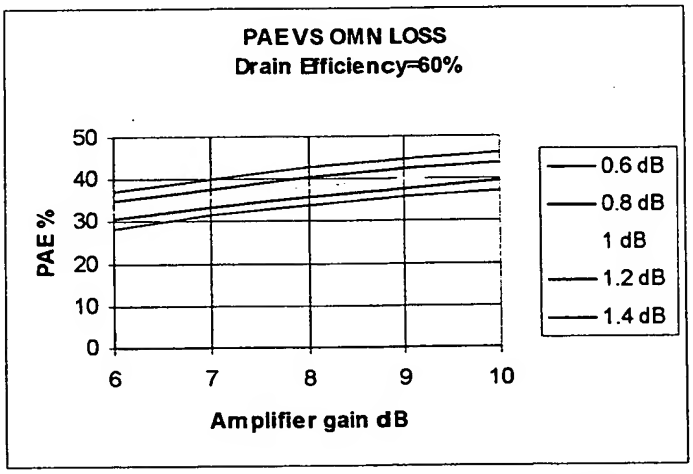

Figure 1: Amplifier PAE as a function of gain for different values of output matching network (including balun)

INVENTOR(S) SIGN AND DATE: L. Noyce 1/6/03					
WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN		1/6/03	G. MECA		1/6/03

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2. The push-pull amplifiers desi_ ed based on class A, B, A-B or C, (g_ rally known as current-source amplifiers) suffer from low inherent PAE due to the overlapping voltage & current waveforms at the device terminals. This mode of operation causes power dissipation within the device, hence lower efficiency.

Our design approach would eliminate the above mentioned performance limitations by employing the following three major concepts (claims) that have not been used in prior arts for the design of broadband push-pull highly efficient (PAE 80%) amplifiers:

Claim No.1

1- The amplifiers are designed to operate in the switching mode (class-E) operation with demonstrated performance of PAE >90% at S-band and 70% at X-band.

Under ideal conditions, class-E amplifiers operate as a perfect switch with no overlapping voltage & current waveforms at the device terminals, thereby dissipating zero power (100% collector or drain efficiency) as depicted in Figure 2. Other classes of amplifiers operate as a current-source with overlapping voltage & current waveforms and hence lower efficiency.

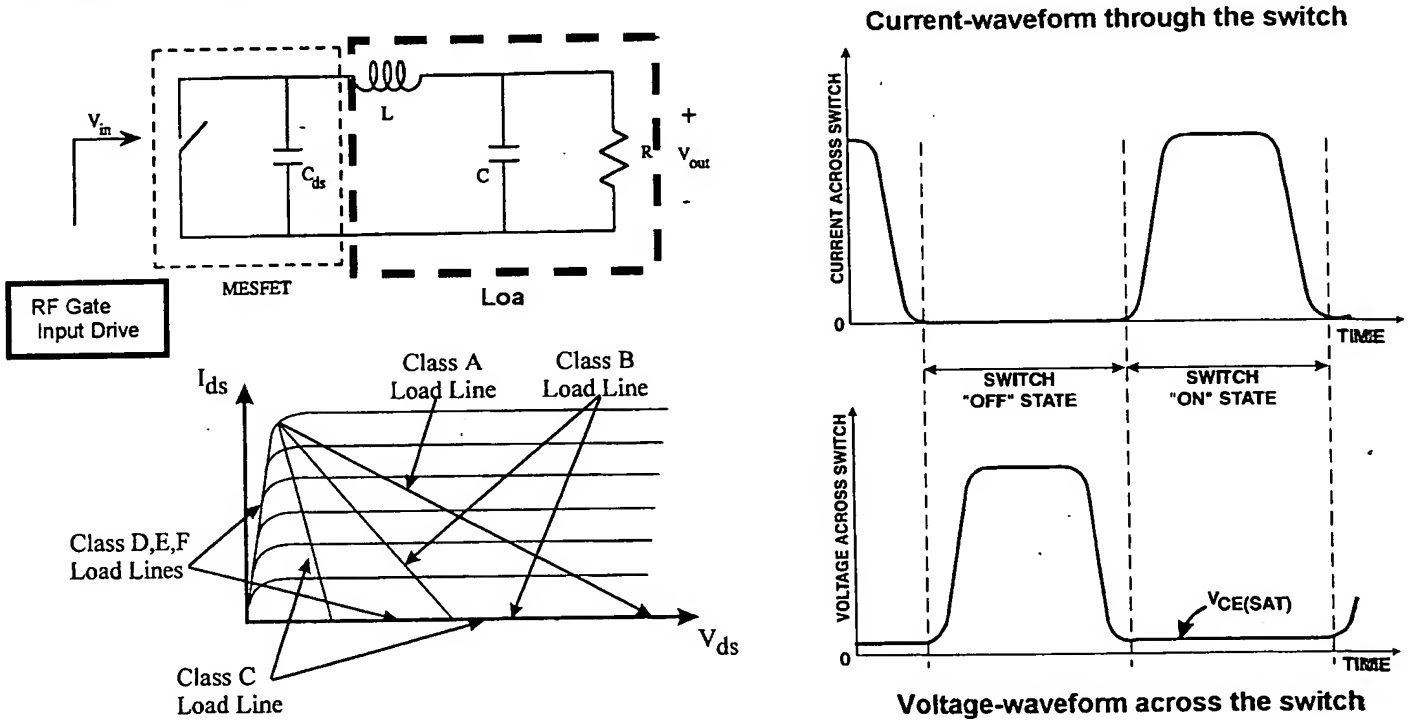

Figure 2: Ideal switching mode class-E amplifier topology showing ideal switching device (MESFET and the ideal class-E load) & ideal output waveforms.

INVENTOR(S) SIGN AND DATE: R. Gruyre 1/6/03					
WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN	J.A. Maupin	1/6/03	G. MECA	G. Meca	1/6/03

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We have developed a simple, yet accurate, design methodology for successful realization of switching mode, class-E high efficiency power amplifiers. Furthermore, a technique for modifying pHEMT large-signal model has been developed that yields a more accurate modeling of switching mode amplifiers. Our proposed circuit design and simulations includes time domain analysis, Harmonic Balance analysis, and large signal stability analysis. The robust design methodology has yielded two first pass design successes achieving world record class-E HPA performances.

- The first successful design and fabrication of a highly efficient S-band monolithic CPW class-E amplifier that employs a 0.3 um x 1000 um pHEMT. As shown in Figure 3, the amplifier measured performance shows a peak Power Added Efficiency (PAE) of more than 90% and a peak output power of greater than 23 dBm at 3.25 GHz.
- The first successful design and fabrication of an X-band monolithic high efficiency class-E amplifier that employs a 0.3 um x 600 um pHEMT. As shown in Figure 4, the amplifier's measured performance shows a peak Power Added Efficiency (PAE) of 63% at 10.6 GHz and a constant output power of greater than 24 dBm together with a gain of 10 dB over 9-11 GHz.

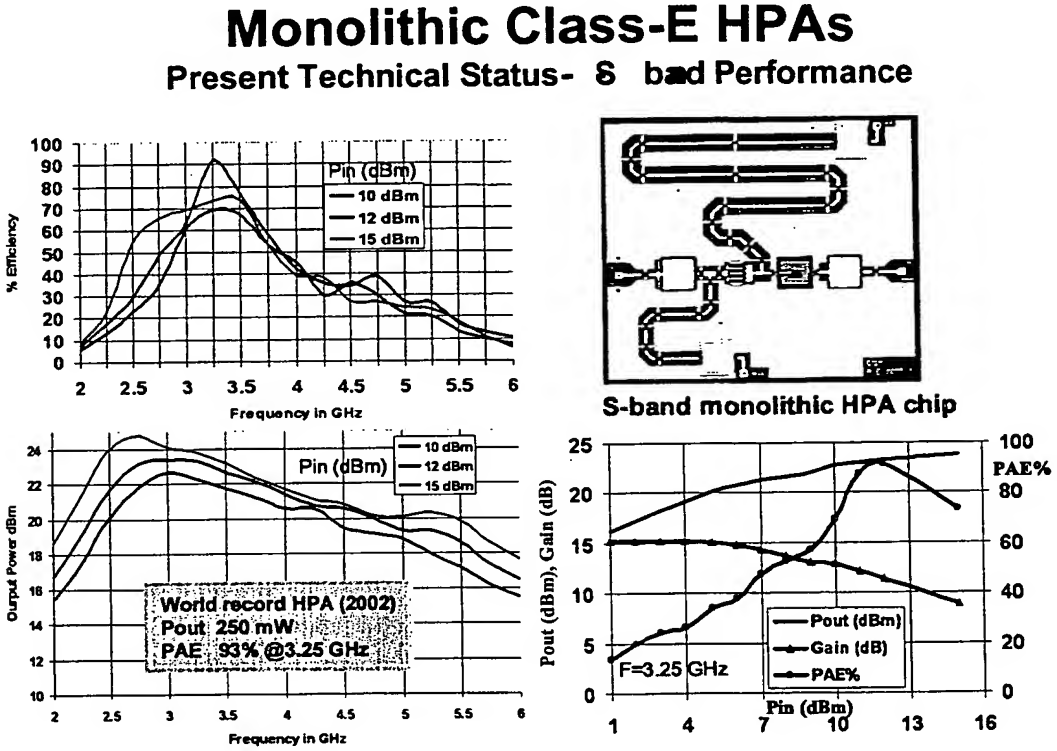

Figure 3: Measured performance of class-E S-band HPA

INVENTOR(S) SIGN AND DATE: R. Joyce 1/6/03					
WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN	J.A. Maupin	1/6/03	G. MECA		1/6/03

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Monolithic Class-E HPAs

Present Technical Status- X band Performance

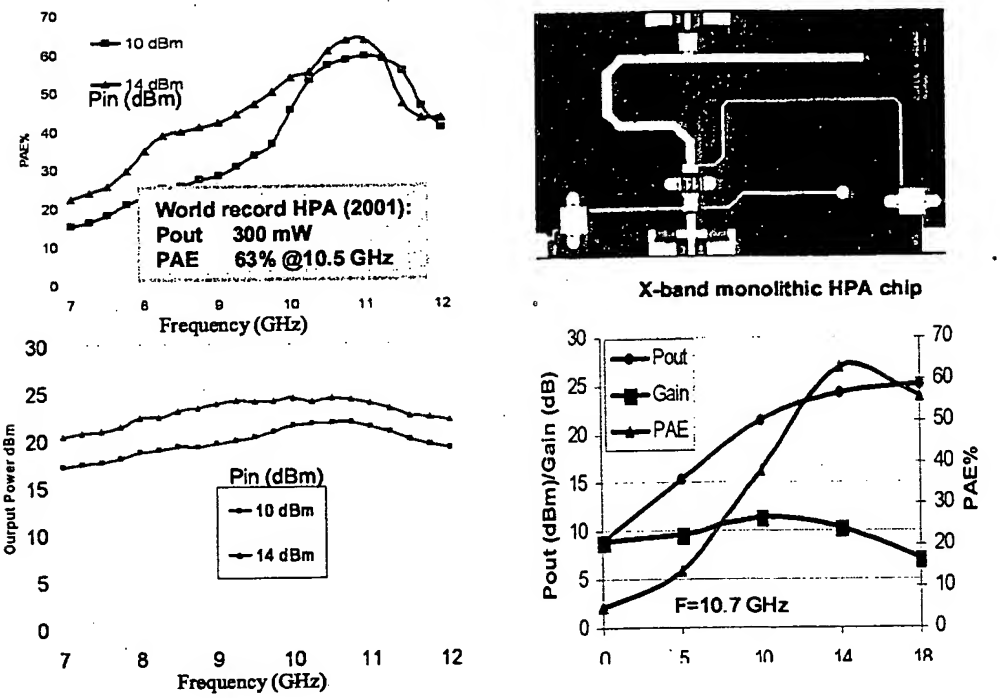

Figure 4: Measured performance of class-E X-band HPA

Claim No.2

- **The push-pull amplifier design is based on utilizing a novel miniature low-loss slotline balun having an insertion loss of <1 dB at X-band and <0.5 dB at S-band.**

This novel miniature balun eliminates the usage of an ordinary 180 degrees hybrid (balun) for power splitting and combining purposes, thereby reducing the associated circuit loss which results in a compact and highly efficient push-pull HPA. . Our proposed miniature balun has demostrtated an ultra broad bandwidth performace from dc to 10.0 GHZ. The balun shown in Figure 5 has been optimized for minimum loss of 0.5 dB across 2-6 GHz frequency band. Several slotline balun were designed, fabricated and measured to demonstrate the usefulness of this invention. These miniature broadband baluns are simple to fabricate and easy to integrate with SiGe or GaAs technologies.

INVENTOR(S) SIGN AND DATE: R. Mayer 1,6,03					
WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN	J.A. Maupin	1/6/03	G. MECA		1/6/03

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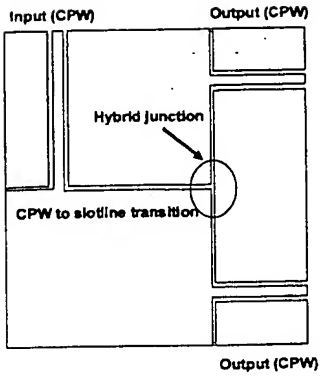

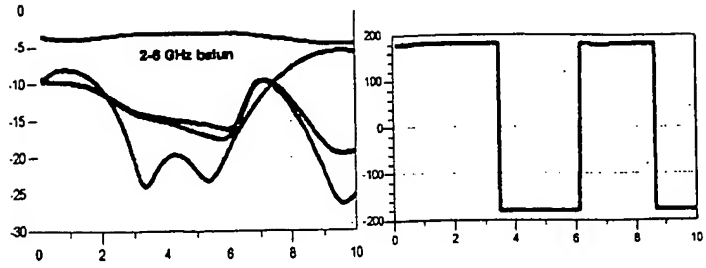

Figure 5: Miniature balun with integrated CPW to slotline transitions (0.5 x0.5 mm)

Claim No.3

- **Thin film Barium strontium titanate (BST) is used as tunable capacitor to tune the class-E HPA's load for operation over a broad bandwidth.**

Raytheon Infrared Operations (RIO) has developed the materials and processes necessary to fabricate high quality barium strontium titanate (BST) varactors using a spin-on MOD (Metal Organic Decomposition) process. Typical tunability range is greater than 5 to 1 with a control voltage range of 0 to 30 volts dc Typical "Q" is much greater than 100 at 30 MHz. Raytheon has fabricated a wide variety of plate capacitors with values ranging from 15 pF to 2200pF. These devices have been tested at frequencies up to 1 GHz. Other types of capacitor structures such as co-planar and interdigitated designs can be fabricated using this process. Such structures would be appropriate for microwave applications.

For example, Figure 6 shows a tunability curve for an MIM BST varactor, with a 160nm thickness and an active area of 20x100 microns. The capacitance density in this case is ~32fF/um^2 (dielectric constant of ~580) which is nearly a factor of 100 larger than a typical SiN capacitor! The measured tunability is over 6:1 in the 0-20V range (the breakdown voltage for this device is 22V).

INVENTOR(S) SIGN AND DATE:					
WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN		1/6/03	G.MBCA		1/6/03

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	GaAs	BS	MEM
Tunabilit (at high	Mediu (2-5:1 typ)	Hig (6-:1 typ)	Lo (<1.5:1)
RF (Q	Goo (Q<60typ	Goo (Q<60typ)	Very (Q<200)
Control	<10V (unipola)	< -20V (bipolar	40-90 V (bipolar
Tunin Spee	Fast	Fast	Slo
Powe Handlin	Poo	Excellent	Goo
IMD	Poo	Excellent	Excellent
Packagin	Hermetic	Surface -	Hermetic
Cost	Moderate to	Lo	Moderate

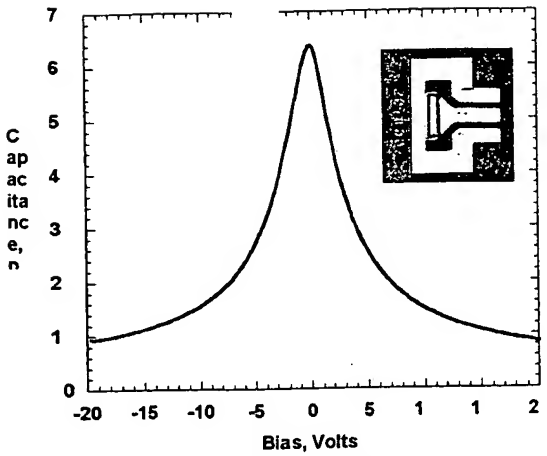

Figure 6. (Left) Comparison of Characteristics of BST Varactors with GaAs Varactors and MEMs. (Right) Capacitance Variation (pF) versus Bias (Volts) for a 20x100 um BST MIM Varactor Fabricated with a 160nm Thickness.

Claim No.4

- **By utilizing the above three aforementioned claims and in conjunction with the useful properties of MMIC technology, a new generation of highly efficient HPAs can be designed. These HPAs are suitable for insertion in SBR and other avionics systems where efficiency is a paramount premium.**

The push-pull HPA has a number of advantages over single-ended amplifiers, including the potential for broadband performance and twice the output power of a single-ended amplifier. The push-pull HPA architecture is shown in Figure 7. The input power is split and fed in anti-phase to the two pHEMTs through the miniature low-loss slotline balun which was described under claim # 2. Figure 8, shows the fabricated balun realized on Alumina substrates.

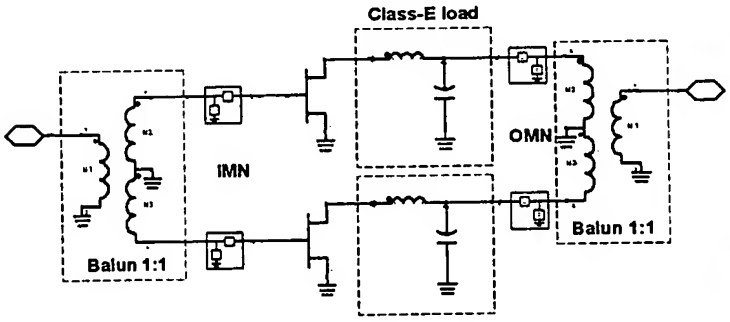

Figure 7. Proposed non-tunable class-E push-pull HPA

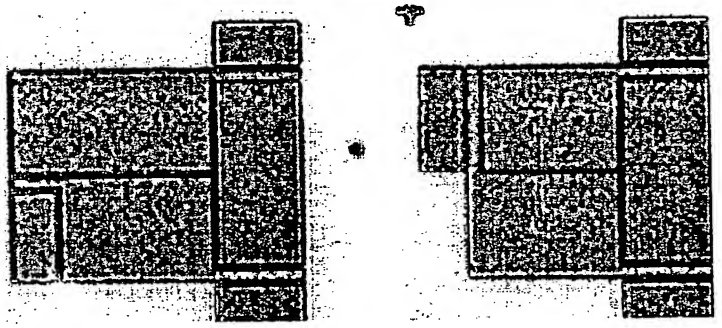

Figure 8. Fabricated miniature balun with integrated CPW to slotline transitions

INVENTOR(S) SIGN AND DATE: R. DeWeese 1/6/03					
WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
J.A. MAUPIN	J.A. Maupin	1/6/03	G. MBEA	[signature]	1/6/03

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Figure 9 depicts a new circuit idea for realizations of a tunable broadband high efficiency push-pull HPA that uses BST capacitors to provide broadband tuning. Figure 10, illustrates a novel version of an H-bridge circuit suitable for MMIC implementation. This circuit topology is capable of producing higher output power when compared with the push-pull topology.

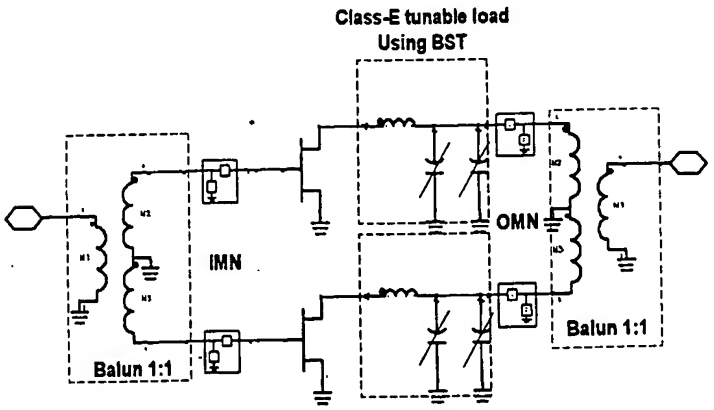

Figure 9. Tunable class-E push-pull HPA using BST tuning capacitors

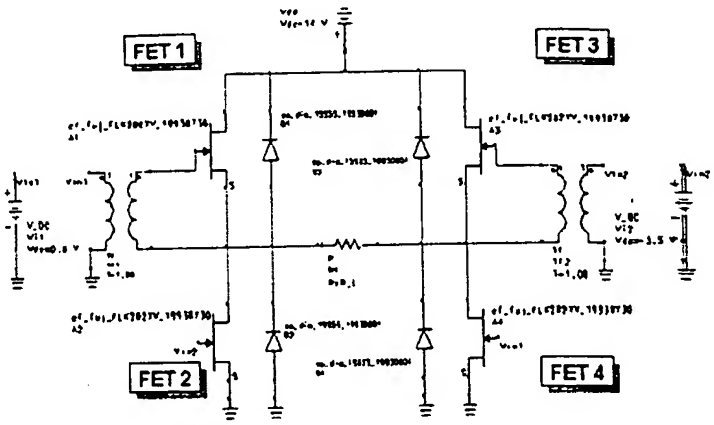

Figure 10. High power H-bridge class-E circuit

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WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE	WITNESS NAME (PRINT)	WITNESS SIGNATURE	DATE
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